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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
G05B 19/418, 19/042

A1

(11) International Publication Number: WO 99/31559

(43) International Publication Date: 24 June 1999 (24.06.99)

(21) International Application Number: PCT/US98/24223

(22) International Filing Date: 12 November 1998 (12.11.98)

(30) Priority Data:
08/993,770 18 December 1997 (18.12.97) US

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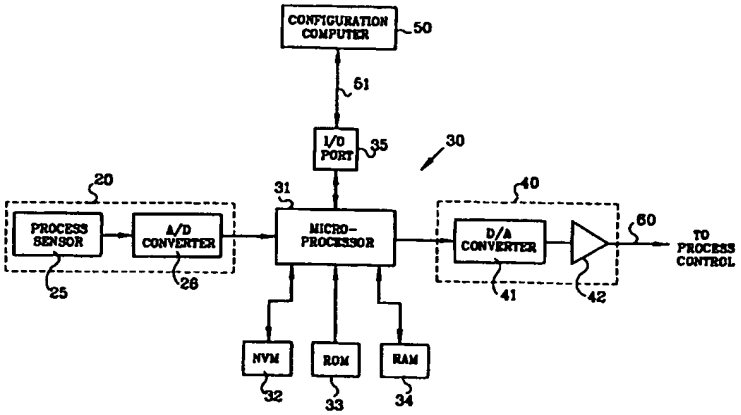
(81) Designated States: AU, CA, CN, JP, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: FIELD PROGRAMMABLE INDUSTRIAL PROCESS TRANSMITTER



(57) Abstract

An arrangement is disclosed for altering in the field the operating instructions used by an industrial process transmitter to collect, manipulate and transmit output signals representing the state of an industrial process. The arrangement includes an alterable storage device that has a first set of operating instructions stored therein that characterize the operation of the industrial process transmitter. A controller device connected to the alterable storage device is arranged to use the stored instructions to control the industrial process transmitter. A configuration device connectable to the industrial process transmitter, is arranged to accept a second set of operating instructions entered by a user. Upon establishment of the commmunication link between the configuration device and the industrial process transmitter, the configuration device transmits the second set of operating instructions to the industrial process transmitter, where they are stored in the alterable storage device, replacing the first set of operating instructions. The controller device then uses the second set of operating instructions to collect, manipulate and transmit the output signals representing the state of the industrial process. Alternatively, the arrangement can be used to alter in the field functional process routines or instructions that are used in the calculation of a derived output signal from the collected process signals. The functional process routines that are programmmed into the alterable storage device can either replace previously–stored routines or add new functional routines to a previously–stored set.

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FIELD PROGRAMMABLE INDUSTRIAL PROCESS TRANSMITTER

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is related to co-pending application, Serial No. 08/993,769, titled "A Method for Field Programming an Industrial Process Transmitter", filed on the same date herewith, and having a common assignee as the present invention.

FIELD OF THE INVENTION

This invention relates in general to process signal transmitters and, more specifically, to a process signal transmitter that is capable of accepting configuration programming downloaded to the transmitter in the field.

BACKGROUND OF THE INVENTION

The present invention is used with devices known as "smart two-wire process transmitters" that must be set up or configured in one of a multitude of modes depending on the application. Signal transmitters accept one form of various low-level signals from a sensor or transducer and convert such signals to a standard form known as a 4-to-20-mA current loop. Such transmitters are used in the process industries and are used for measuring temperature, pressure, flow, level and various other variables associated with the process (hereinafter referred to as a process variable).

Generally, to measure each of these different process variables a different design transmitter is required. Transmitters that are designed using classical analog circuit technology even require different models of transmitters depending on the range of the measured variable. Typically, a transmitter receives a low level (microvolt and millivolt level) signal from thermocouples, pressure, flow, level and other sensors; converts these low-level signals near the location of the sensor to a suitable high-level signal, and transmits such high-level signal to a remote location within a process plant, such as the control room. Alternatively, the signal output can also be transmitted to a process control system associated with industrial process that is used to monitor, collect and manipulate the process variables.

In recent years "smart" process transmitters have been introduced. These devices are distinguished from their analog predecessors by utilizing one or more microprocessors for their operation. These so-called smart transmitters easily implement digital communications with a digital terminal or other digital computer. All current smart two-wire transmitters offer some form of digital communication with either local terminals or to a process control systems central computer. Additionally, some smart two-wire transmitters include internally-stored programming instructions that manipulate in one form or another the process variables received from the sensors. This manipulation can be as simple as selecting a sensor, or as complicated as deriving and transmitting to a process control system an output signal indicative of the product of an algorithmic calculation using the process values sensed.

Presently known smart transmitter's operating and configuration programs are normally stored in a Read Only Memory (ROM). The operating and configuration instructions loaded in the ROM characterize the process transmitter and defines its functionality. The term characterize is used in this invention to describe the character of the device, or that which operationally distinguishes the process transmitter from other process transmitters, such as, a transmitter that senses and transmits pressure signals from a transmitter that senses and transmits flow signals. The term functionality is defined as the operating behavior of the process transmitter within its character role, such as in a temperature transmitter, the frequency that a temperature sensor is polled by the transmitter to gather process variable data; or in a multi-variable transmitter, the algorithmic routines used to derive and calculate a manipulated variable from one or more process variables sensed and collected. The ROM is programmed and assembled into the transmitter at the time of manufacture. In order to change a transmitters character and functionality, the transmitter has to be removed from the process, opened, and the ROM physically removed and replaced with a new ROM.

This has many undesirable consequences. First, the removal of the transmitter effectively stops the monitoring and collection of the variables associated with that portion of the process. If these process variables are critical to the product being

produced, the loss of this information may necessitate the temporary shut-down of the manufacturing or industrial process. This may a have a negative economic impact on the manufacturer due to the loss of production and the cost of starting-up production again. Second, the opening of the transmitter and physical replacement of the ROM has inherent dangers in the damage to the electronic and electrical components and circuits of the device. Static electrical discharges and undue mechanical strain and other dangers associated with physically handling of sensitive low-power electrical devices can leave these devices non-functional, requiring replacement of the damaged circuits or devices, or replacement of the entire transmitter.

An apparatus for configuring a smart transmitter is taught by U.S. Patent 5,083,288, to Somlyody et al. This invention teaches an apparatus for configuring a smart transmitter that uses switches to configure the transmitter to perform various functions. The transmitter includes a program, and an apparatus for cycling through the program, to set various conditions, including a range of operation and selection of one of many possible remote sensors. The program includes two portions, each of which can

be entered by a user-manipulated switch. Each portion of the program can be cycled through and as selected portions of the program are reached, a selected parameter can be set into the microprocessor as a permanent operating condition. The set operating conditions can be set or reset at any time by cycling through the program in accordance with the set protocol.

The apparatus and method described above has limitations in that any configuration programs that changes the functionality of the device has to be loaded initially into the transmitter at the time of manufacture, thereby limiting its functionality to the operating characteristics that have been previously loaded. Additionally, there are no provisions in the initial programming that can change the character of the transmitter.

SUMMARY OF THE INVENTION

Therefore, there is provided by the present invention, an arrangement for altering in the field the operating instructions used by an industrial process transmitter to collect, manipulate and transmit output signals that represent the state of an industrial process.

The arrangement is comprised of an alterable storage device that has a first set of operating instructions stored therein that characterize the operation of the industrial process transmitter. A controller device connected to the alterable storage device is arranged to use the operating instructions stored in the alterable storage device to control the industrial process transmitter. A configuration device is arranged to accept a second set of operating instructions entered by a user and to establish a communications link between the configuration device and the controller device. Upon establishment of the communication link, the configuration device transmits the second set of operating instructions to the industrial process transmitter where they are stored in the alterable storage device, replacing the first set of operating instructions. The controller device then uses the second set of operating instructions to collect, manipulate and transmit output signals representing the state of the industrial process.

Alternatively, the arrangement of the present invention can be used to alter in the field functional process routines or instructions, such as algorithm routines, that are used in the calculation of a derived output signal from the collected process signals. The functional process routines that are programmed into the alterable storage device can either replace previously-stored routines or add new functional routines to a previously-stored set.

Accordingly, it is an object of the present invention to provide an industrial process transmitter that is field programmable.

It is another object of the present invention to provide a process transmitter that can accept user-defined configuration data from a configuration device in order to change the operating character and functionality of the process transmitter.

It is still another object of the present invention to provide an industrial process transmitter that will accept user-defined custom algorithm routines and that uses the downloaded custom algorithm routines along with sensed process variables to develop output signals representing the state of an industrial process.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects, features, and advantages of the present invention will be apparent from the following description of a preferred embodiment thereof, taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a schematic block diagram of the major components of an industrial process transmitter where the present invention is used to advantage;

FIGURE 2 is a schematic block diagram showing the key components of the field programmable industrial process transmitter in accordance to the present invention;

FIGURE 2A is the schematic block diagram of FIGURE 2, showing an alternative arrangement of linking a configuration computer to the process transmitter in accordance to the present invention; and

FIGURE 3 is a block diagram of the steps involved in programming the process transmitter in accordance to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Turning to FIGURE 1, the major components of a presently known industrial process transmitter 10 are illustrated (hereinafter referred to as a process transmitter). The major components of the process transmitter include one or more process sensor packages 20, 20', a field device controller 30 and a process signal translation device 40. These three major components can be all housed together within a single housing, or the field device controller 30 and process signal translation device 40 housed within a single package and the process sensor packages 20, 20' located remotely. The process sensor packages 20, 20' each include a process-specific sensor that is tasked to sense a

particular aspect of the process being monitored or controlled, such as, temperature, pressure, flow, etc.

The signals generated by the sensors 20, 20' are passed to a field device controller 30 where they are manipulated. The field device controller for this embodiment is contemplated to be a so-called "smart", or microprocessor-controlled, device. The microprocessor controller of this class of device controls the operation of the process transmitter 10 and is also tasked under programmed instructions loaded at the time of manufacture to manipulate the sensor signals received. For example, in a multi-variable process transmitter that is characterized or intended to be used to gather and transmit output signals indicative of the pressure of a process medium, temperature is also sensed since the temperature of the medium can affect the accuracy of the pressure readings. The programmed instructions loaded into the field device controller 30 not only control the selection and frequency of the polling of the sensor packages 20, 20', but also, under control of an algorithm routine, can calculate the corrected pressure by factoring in the temperature of the process medium. Therefore, the process variable output by the field device controller 30 is the product of the algorithm routine.

The output of the field device controller 30 is next applied to a process signal translation device 40. As can be appreciated by those skilled in the art, a microprocessor-controlled field device controller is a digital device. Many existing process plant networks use the so-called two wire 4-to-20-mA current loop for the transmission of process signals from various locations in the plant to a control room. The two-wire transmission system is also used to supply power to the process transmitter. The power supply section of the process transmitter is not shown in this embodiment, but is well known to those skilled in the art. The process signal translation device 40 converts the digital signals output by field device controller 30 into an output signal that can be transmitted on the two wire 4-to-20-mA current loop. Alternatively, in modern industrial plants that use digital local area networks the process signal translation 40 can be a digital signal packeting method that gathers, formats and packages the process signals developed by the field device controller 20 into message packets or other messaging forms required for transmission on the local area network.

Turning now FIGURE 2, the key components of the field programmable process transmitter in accordance to the present invention are illustrated. As can be seen, the process sensor package 20\is comprised of a process sensor 25 and an analog-to-digital converter 26. Sensor 25 is in communication with the measured process medium and continually outputs an analog voltage representation of the sensed activity. Sensor 25 if measuring, for example, the flow of a process medium such as a gas or liquid through a conduit or valve, would output an analog output voltage that represents the rate of flow observed by the sensor. The analog output signals from sensor 25 are converted into digital signals by analog-to-digital converter 26 before being applied to microprocessor 31. Field device controller 30 further includes a Read Only Memory (ROM) 33 that is normally programmed at the time of manufacture and contains operating instructions associated with the initiation, shut down, testing and general operating instruction of the microprocessor 31. A Random Access Memory (RAM) 34 is also included that is used to store on a temporary basis intermediate results of any operational routine or subroutine calculation.

A Non-Volatile Memory device (NVM) 32 is also connected to microprocessor 31. The NVM device 32 is of a type of device well known to those skilled in the art that is electrically erasable and programmable, or alterable, and is capable of retaining the data stored in the device if power is removed. Specifically, the invention contemplates the use of a solid-state memory device that can be altered by having either the entire memory or selected portions of the memory erased by an electric signal and new data stored in the erased portions. The most commonly used solid-state memory device having the aforementioned features is the Electrically Erasable Programmable Read Only Memory (EEPROM). However, other new Non-Volatile memory devices such as the so called solid-state Flash Memory or the Non-Volatile Random Access Memory (NVRAM), that combines in a single package an EEPROM and a static RAM, can be effectively used to perform the function of NVM 32. Additionally, low-power CMOS RAM devices that are normally associated with a battery backup supply can also be effectively used as the NVM 32. The NVM 32 is used by the present invention to accept and store therein operational programming downloaded to the industrial process

transmitter in the field, that characterizes and operationally distinguishes the process transmitter from other process transmitters and the operational routines that define operating behavior of the process transmitter within its character role.

The term characterize is used in the present invention to describe the character of the device. Defined as that which operationally distinguishes the process transmitter from other process transmitters, such as, a transmitter that senses and transmits pressure signals from a transmitter that senses and transmits flow signals. The term functionality is used in the present invention to define an operating behavior of the process transmitter within its character role, such as in a temperature transmitter, the frequency that a temperature sensor is polled by the transmitter to gather process variable data.

The characterizing programming and the data defining the process transmitters functionality is downloaded to the field device controller 30 via an I/O port 35 that is connected to microprocessor 31. I/O port 35 connects the process transmitter to a configuration computer 50 via a digital line 51. The configuration computer 50 can be any one of a type of presently known microprocessor controlled devices such as desk top, portable or hand held computer devices that can be manipulated by a user to enter characterizing programming or functionality defining routines into the field device controller 30. The configuration computer 50 establishes a communications link to the microprocessor 31 via digital line 51 in any of the present forms known for communicating and transferring data between two digital devices. The link can be a local serial data link and, therefore, composed of a two-line conductor or a local parallel data link composed of a plurality of conductors.

Programming data and functional routines entered by the user and downloaded to the microprocessor 31 are finally loaded into NVM 32 and become a part of the operational programming of the process transmitter. If the sensors 25 connected to the field device controller 30 are tasked to read process flow, a user via the configuration computer can create new flow equations or algorithm routines that can calculate an output value that can factor in other variables such as previously sensed process variables, parameters, offsets, gains, etc. Additionally, the programmable process

transmitter of the present invention can have its character easily changed in the field by downloading the appropriate operating programming and data subroutines to NVM 32 via configuration computer 50. By connecting the appropriate process sensor package 20, i.e. thermocouples, or temperature sensors, a process transmitter originally configured to measure flow can be changed to a temperature transmitter easily without the need to purchase and install a new process transmitter.

The value of a calculated or manipulated process variable is output to the process signal translation device 40 for conversion into a signal compatible with the signal network used in the plant. In FIGURE 2, the plant signal network is the 4-20-mA current loop 60. The digital output value from microprocessor 31 is applied to a digital-to-analog converter where the digital signal is translated into an analog voltage for amplification by an amplifier 42 before being transmitted along current loop 60 to a process control or monitoring scheme. The process control scheme can be as simple as visually displaying the output value on an indicator, meter or CRT either locally in proximity of the process transmitter, or remotely in a control room. The output analog signal can also be transmitted to a local controller of an automated distributed process control system. The local controller gathers the output values from the process transmitters associated with the controller and is passed to the process control system. The process control system controls the process in accordance to the values so received.

Turning to FIGURE 2A, an alternative arrangement of linking the configuration computer 50 to the process transmitter in accordance to the present invention is shown. There is known in the process industry a class of handheld devices used to communicate with process transmitters that can communicate digital and analog data over the so called two-wire 4-20-mA current loop. Such a device and the method of communication is taught by U.S. Patent 4,520,488, entitled, "Communication System and Method", having a common assignee as the present invention and hereby incorporated by reference.

Using the communication method of the above-identified patent the configuration computer 50 can be connected anywhere along the so-called two-line

current loop 60 via a communication line 61. The configuration computer 50 includes a driver/receiver circuit (not shown) as taught by the aforementioned U.S. Patent 4,520,488, which introduces direct current variations in the two-line current loop 60, between pre-set current limits, with each variation representing a digital bit. The user-entered programming and data is applied to the two-wire current loop 60 via line 61 and received by an associated process transmitter driver/receiver device 70. The device 70 translates the direct current variations representing digital data and outputs the data to microprocessor 31. Microprocessor 31 then stores the downloaded programming and data into NVM 32.

Turning now to FIGURE 3, a block diagram of the steps involved in programming the process transmitter in accordance to the present invention is illustrated. In order to simplify the explanation of the concept involved in the field programming of the process transmitter, the data to be entered will be explained as an algorithm routine. It will be well understood by those skilled in the art that other forms of data, such as, operating instructions, characterization data, or the like, may be effectively downloaded by the method illustrated and the invention is not limited thereto.

A user utilizing the configuration computer 50 enters the algorithm routine to be downloaded into the computer 50 (block 100). The user may input this data using an associated input device (not shown). The input device can be one or more of the many devices presently known for inputting data and commands into a computer device. For example, a keyboard where the user manually enters via keystrokes the algorithm routine, a selection from a preloaded list of possible algorithm routine choices displayed on a CRT screen, and/or from magnetic media device such as a floppy disk drive, or the like.

Once the algorithm routine is entered in the configuration computer 50, the computer, under control of an operating program, converts the routine into machine code readable by microprocessor 31 (block 110). Next the configuration computer 50 establishes a communications link with microprocessor 31 of the process transmitter

(block 120). The microprocessor 31, upon receiving the request to establish the link from configuration computer 50, prepares to receive the download and sends an acknowledgment to configuration computer 50 to begin the transfer.

The now machine code translated algorithm routine is transmitted to process transmitter via line 51 (block 130) for a digital connection shown by FIGURE 2, or line 61, to current loop 60 shown in FIGURE 2A. The algorithm subroutine is then stored in a non-volatile memory storage device, in this embodiment NVM 32 (block 140).

The now downloaded algorithm routine can replace a previously downloaded routine or can be one of a plurality of routines stored in NVM 32 in a library. For example, if the process transmitter is configured as a flow transmitter, the library can include custom user-defined algorithm routines for mass and volume flow. Microprocessor 31 can access the routine library and use one of the custom flow algorithm routines stored thereat to manipulate the sensed process variables.

The present invention has been described with particular reference to the preferred embodiments thereof. It will be obvious that various changes and modifications can be made therein without departing from the spirit and scope of the invention as defined in the appended claims and characterized by means for altering the manipulation of the signals collected by a process control transmitter comprised of: means for storing a first set of instructions; means for controlling arranged to manipulate the collected signals in accordance to the first set of instructions; means for configuring arranged to accept a user-defined second set of instructions and to establish a communications link with the industrial process transmitter transferring the second set of instructions to the means for storing whereby, the means for controlling manipulates the collected signals in accordance to the second set of instructions.

CLAIMS

What is claimed is:

1. In an industrial process transmitter used in an industrial process to collect, manipulate and transmit signals representing the state of said industrial process, an arrangement for altering the character of said industrial process transmitter comprising:

an alterable storage device having a first set of operating instructions stored therein;

a controller device connected to said alterable storage device and in accordance to said first set of operating instructions said controller device controls said industrial process transmitter to collect, manipulate and transmit signals representing the state of said industrial process;

a configuration device arranged to accept a user-defined second set of operating instructions and to establish a communications link with said controller device, transferring said second set of operating instructions to said alterable storage device, replacing said first set of operating instructions whereby said controller device controls said industrial process transmitter to collect, manipulate and transmit signals representing the state of said industrial process in accordance to said second set of operating instructions, altering the character of said industrial process transmitter.

2. The arrangement as claimed in claim 1 wherein said second set of operating instructions comprises an operating program that controls the operation of said industrial process transmitter.

3. The arrangement as claimed in claim 2 wherein said alterable storage device is a non-volatile solid-state memory device that can be electrically programmable.

4. The arrangement as claimed in claim 3 wherein said controller device is a microprocessor.

5. The arrangement as claimed in claim 4 wherein said configuration device includes means for entering data into said configuration device arranged to be manipulated by a user to enter said second set of operating instructions into said computer.

6. The arrangement as claimed in claim 5 wherein said microprocessor includes a digital data input port for the reception of digital data and said communications link is comprised of a communications line connecting said digital data input port to said configuration device and said second set of operating instructions is transmitted from said configuration device to said digital data port as digital data in accordance to a communication format, whereby said microprocessor stores said digital data representing said second set of operating instructions by electrically programming said non-volatile solid-state memory device.

7. The arrangement as claimed in claim 6 wherein said communication format is a serial data transmission.

8. The arrangement as claimed in claim 6 wherein said communication format is a parallel data transmission.

9. The arrangement as claimed in claim 5 wherein said industrial process transmitter is connected to a current circuit used in the transmission of output signals from said industrial process transmitter, and said configuration device includes means for transmitting digital data as direct current variations in the current circuit, and said microprocessor is further connected to a process transmitter driver/receiver circuit connected to said current circuit said process transmitter driver/receiver circuit arranged to receive said direct current variations, and said communications link comprises a current loop connecting said configuration device to said current circuit and said second set of instructions are transmitted from said configuration device to said current circuit as said direct current variations and received by said process transmitter driver/receiver circuit and converted to digital data, whereby said microprocessor stores said digital

data representing said second set of instructions by electrically programming said non-volatile solid-state memory device.

10. In an industrial process transmitter used in an industrial process to collect and manipulate signals representing the state of said industrial process, an arrangement for altering the manipulation of the signals collected comprising:

an alterable storage device having a first set of instructions stored therein;

a controller device connected to said alterable storage device arranged to manipulate the signals collected by said industrial process transmitter in accordance to said first set of instructions;

a configuration device arranged to accept a user-defined second set of instructions and to establish a communications link with said controller device for the transfer of said second set of instructions to said alterable storage device whereby said controller device controls the manipulation of the signals collected by said industrial process transmitter in accordance to said second set of instructions.

11. The arrangement as claimed in claim 10 wherein said second set of instructions comprise functional process routines that are used to generate an output signal with the signals collected by the industrial process transmitter.

12. The arrangement as claimed in claim 11 wherein said alterable storage device is non-volatile solid-state memory device that can be electrically programmable.

13. The arrangement as claimed in claim 12 wherein said controller device is a microprocessor.

14. The arrangement as claimed in claim 13 wherein said configuration device includes means for entering data into said configuration device arranged to be manipulated by a user to enter said second set of instructions into said computer.

15. The arrangement as claimed in claim 14 wherein said microprocessor includes a digital data input port for the reception of digital data and said communications link is comprised of a communications line connecting said digital data input port to said configuration device and said second set of instructions is transmitted from said configuration device to said digital data port as digital data in accordance to a communication format, whereby said microprocessor stores said digital data representing said second set of instructions by electrically programming said non-volatile solid-state memory device.

16. The arrangement as claimed in claim 15 wherein said communication format is a serial data transmission.

17. The arrangement as claimed in claim 15 wherein said communication format is a parallel data transmission.

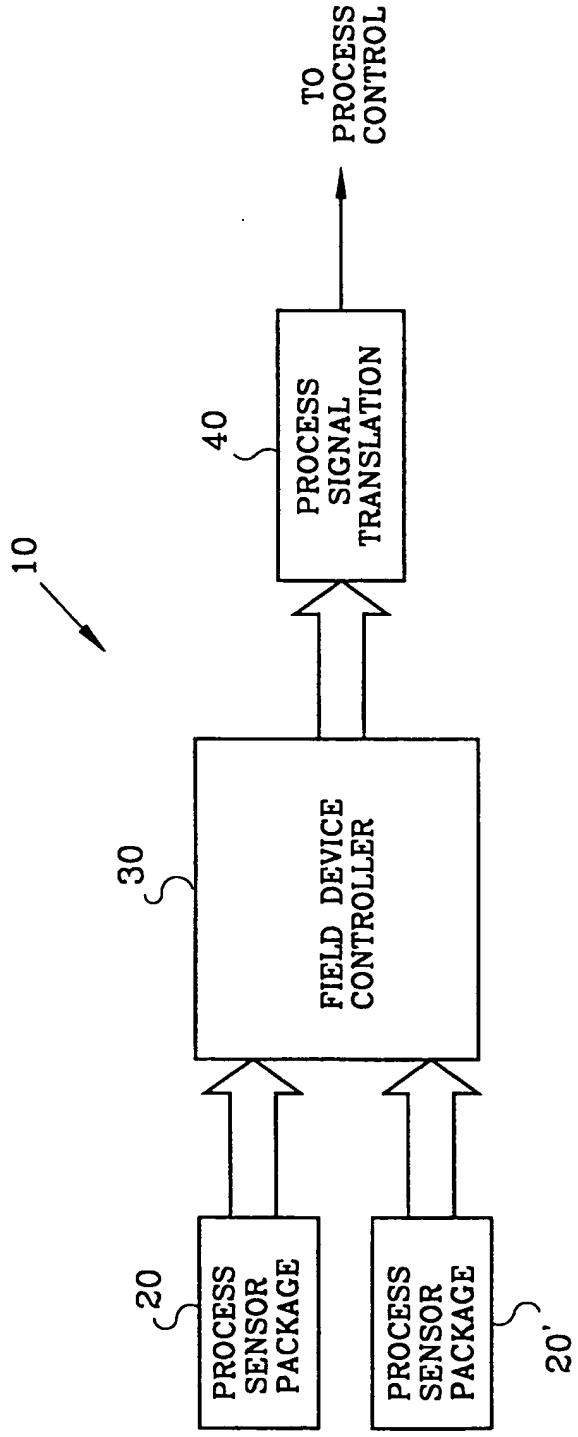
18. The arrangement as claimed in claim 14 wherein said industrial process transmitter is connected to a current circuit used in the transmission of output signals from said industrial process transmitter, and said configuration device includes means for transmitting digital data as direct current variations in the current circuit, and said microprocessor is further connected to a process transmitter driver/receiver circuit connected to said current circuit, said process transmitter driver/receiver circuit arranged to receive said direct current variations, and said communications link comprises a current loop connecting said configuration device to said current circuit and said second set of instructions is transmitted from said configuration device to said current circuit as said direct current variations and received by said process transmitter driver/receiver circuit and converted to digital data, whereby said microprocessor stores said digital data representing said second set of instructions by electrically programming said non-volatile solid-state memory device.

19. In an industrial process transmitter used in an industrial process to collect and manipulate signals representing the state of said industrial process, means for altering the manipulation of the signals collected comprising:

means for storing a first set of instructions;

means for controlling arranged to manipulate said collected signals in accordance to said first set of instructions; and

means for configuring arranged to accept a user-defined second set of instructions and to establish a communications link with said industrial process transmitter transferring said second set of instructions to said means for storing whereby, said means for controlling manipulates said collected signals in accordance to said second set of instructions.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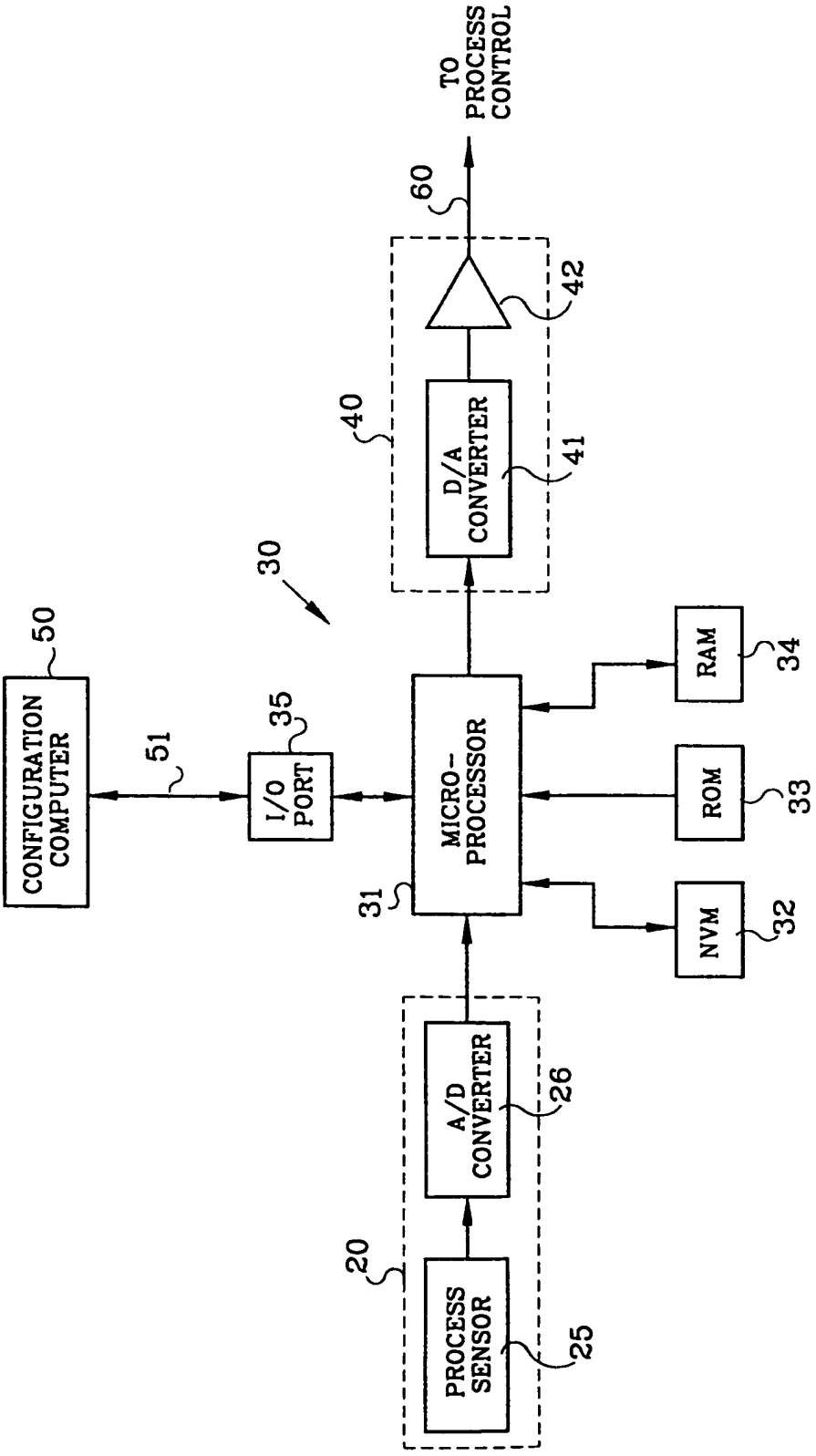
TO PROCESS CONTROL
40
PROCESS SIGNAL TRANSLATION
30
FIELD DEVICE CONTROLLER
20
PROCESS SENSOR PACKAGE
20'
PROCESS SENSOR PACKAGE

Fig. 1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42
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D/A CONVERTER
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CONFIGURATION COMPUTER
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35
I/O PORT
MICRO-PROCESSOR
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34
ROM
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NVM
32
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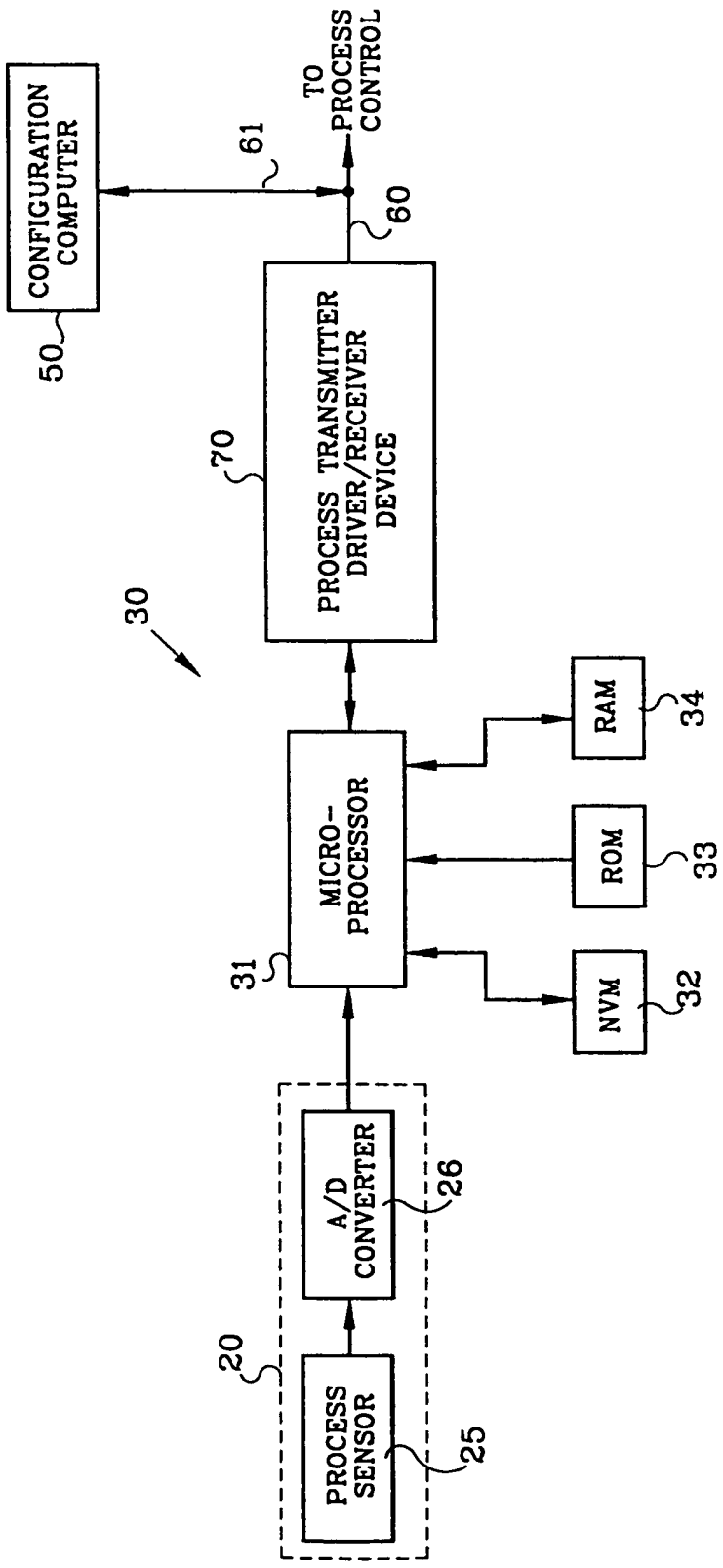
A/D CONVERTER
26
20
PROCESS SENSOR
25

Fig.2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PROCESS SENSOR
25
20

Fig. 2A

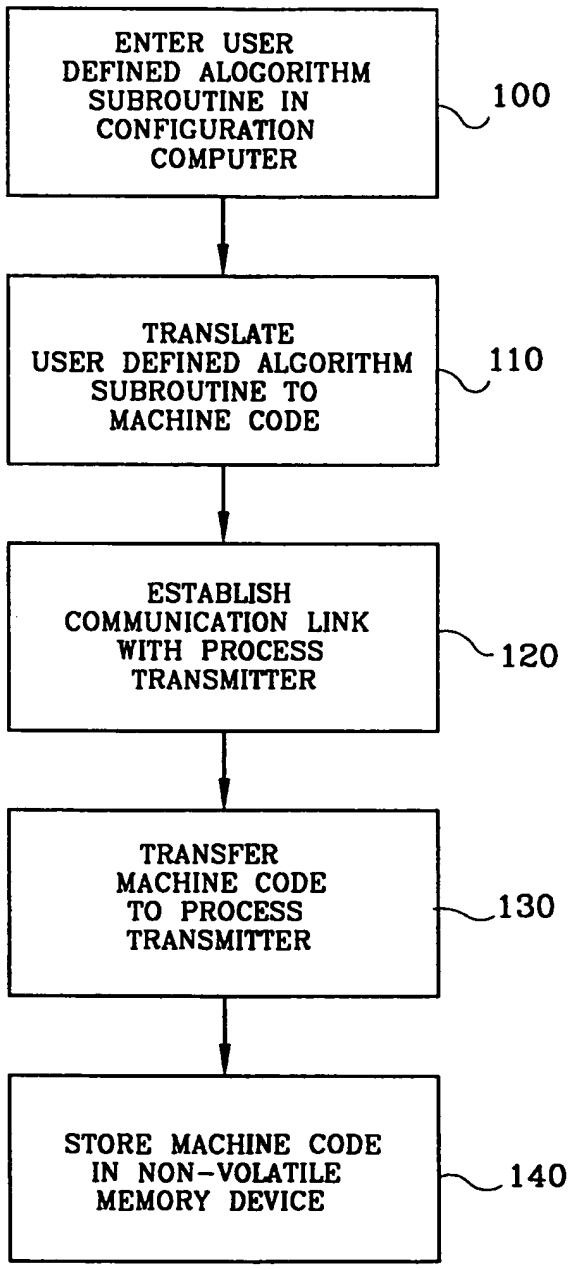
ENTER USER DEFINED ALOGORITHM SUBROUTINE IN CONFIGURATION COMPUTER
100
TRANSLATE USER DEFINED ALGORITHM SUBROUTINE TO MACHINE CODE
110
ESTABLISH COMMUNICATION LINK WITH PROCESS TRANSMITTER
120
TRANSFER MACHINE CODE TO PROCESS TRANSMITTER
130
STORE MACHINE CODE IN NON-VOLATILE MEMORY DEVICE
140

Fig.3

INTERNATIONAL SEARCH REPORT

In..national Application No
PCT/US 98/24223

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G05B19/418 G05B19/042

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 586 305 A (EIDSON JOHN C ET AL) 17 December 1996 see the whole document	1,10,19
Y		2-9, 11-18

Y	DE 41 22 371 A (ROHDE & SCHWARZ) 7 January 1993 see the whole document	2-8, 11-17

Y	DE 44 16 795 A (MANNESMANN AG) 16 November 1995 see the whole document	9,18
A		1-8, 10-17,19

	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 February 1999	04/03/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Hauser, L

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/24223

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 453 736 A (NOREN PETER) 26 September 1995 see the whole document ---	1,10,19
A	EP 0 434 288 A (GE FANUC AUTOMATION NORTH AMER) 26 June 1991 see the whole document -----	1,10,19

1

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INTERNATIONAL SEARCH REPORT

Information on patent family members

In..ational Application No
PCT/US 98/24223

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